Examples of successful applications

Examples of successful applications

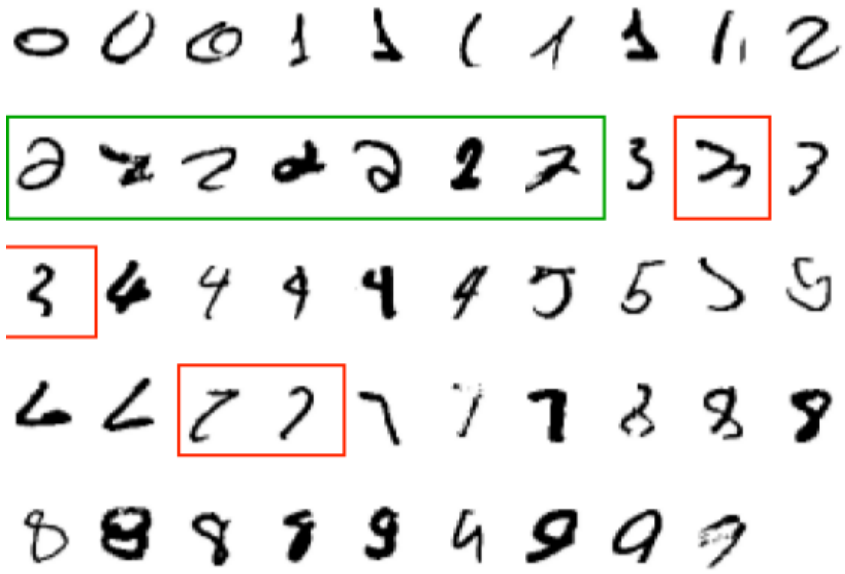
- **Image Processing**
  - Image Classification and Detection
  - Image Segmentation, Scene understanding
  - Style transfer
- **Natural Language Processing**
  - Typical problems
  - Relevant architectures
  - GPT3 playground, ChatGPT
- **Generative modeling**
  - The generative problem
  - Conditional generation
- **Deep Reinforcement Learning**
  - Robot navigation and autonomous driving
  - Planning and simulation

Image Processing

MNIST

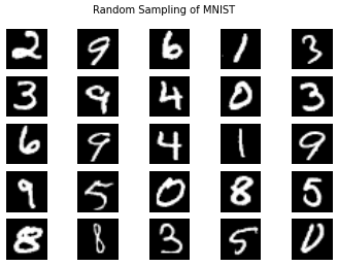
Modified National Institute of Standards and Technology database

- grayscale images of handwritten digits, 28×28 pixels each
- 60,000 training images and 10,000 testing images



MNIST

A comparison of different techniques



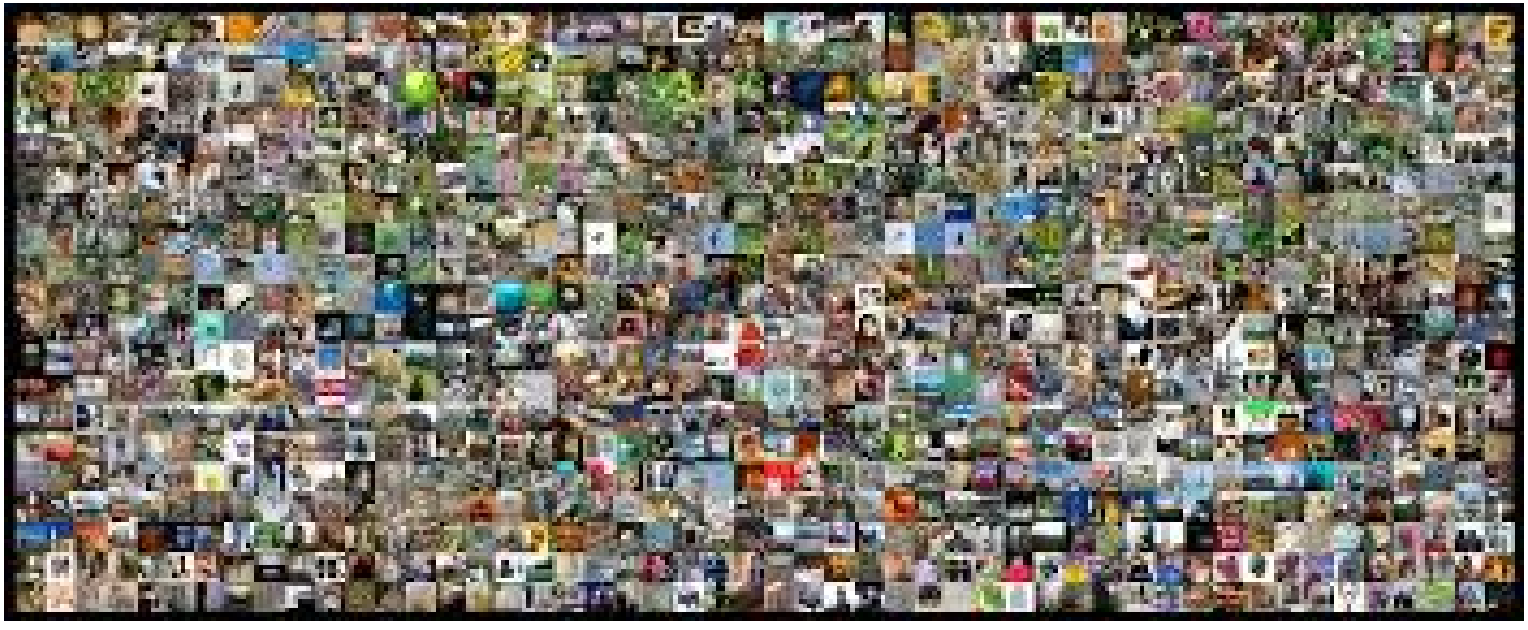
Classifier	**Error rate**
Linear classifier	7.6
K-Nearest Neighbors	0.52
SVM	0.56
Shallow neural network	1.6
Deep neural network	0.35
Convolutional neural network	0.21

See LeCun's page the mnist database for more data.

ImageNet

ImageNet (@Stanford Vision Lab)

- high resolution color images covering 22K object classes
- over 15 million labeled images from the web



ImageNet competition

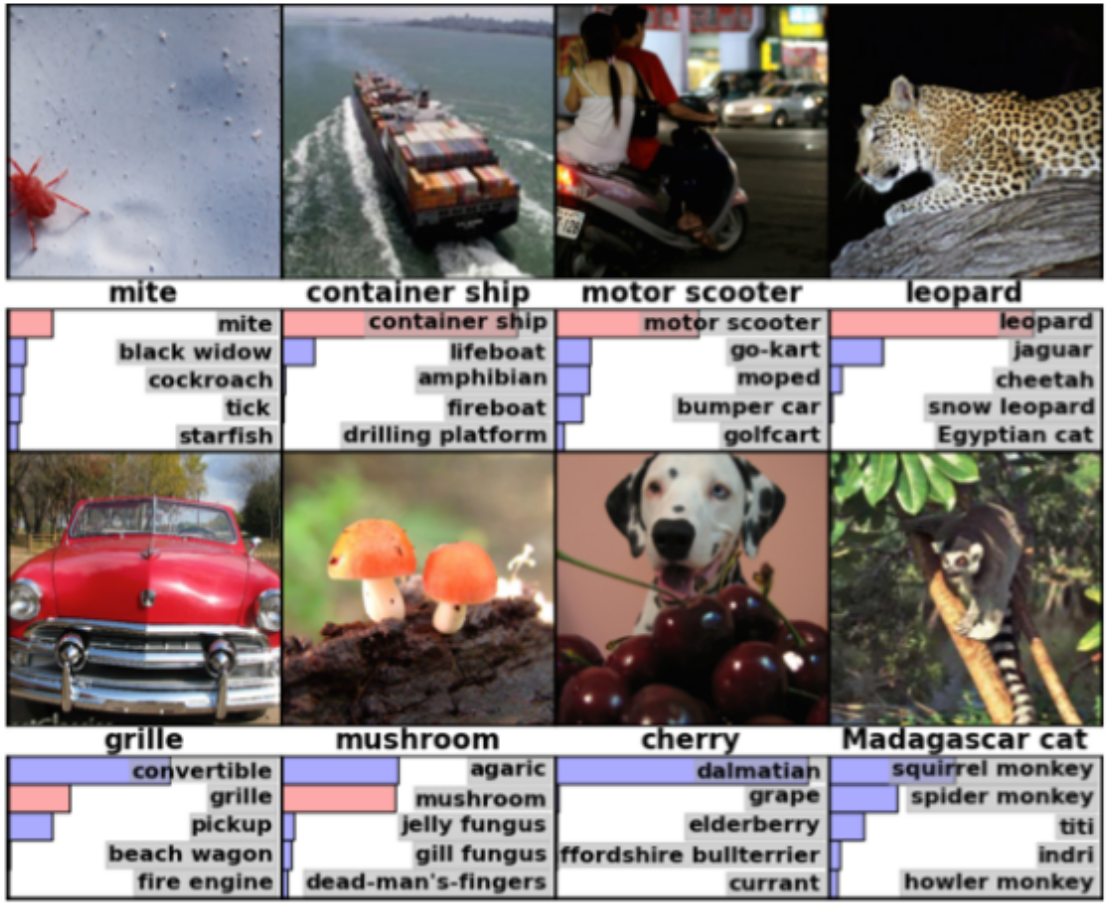
Annual competition of image classification: 2010-2017.

- 1.2 Million images, covering 1K different categories
- make five guesses about image label, ordered by confidence

EntleBucher

Appenzeller

ImageNet samples



ImageNet results

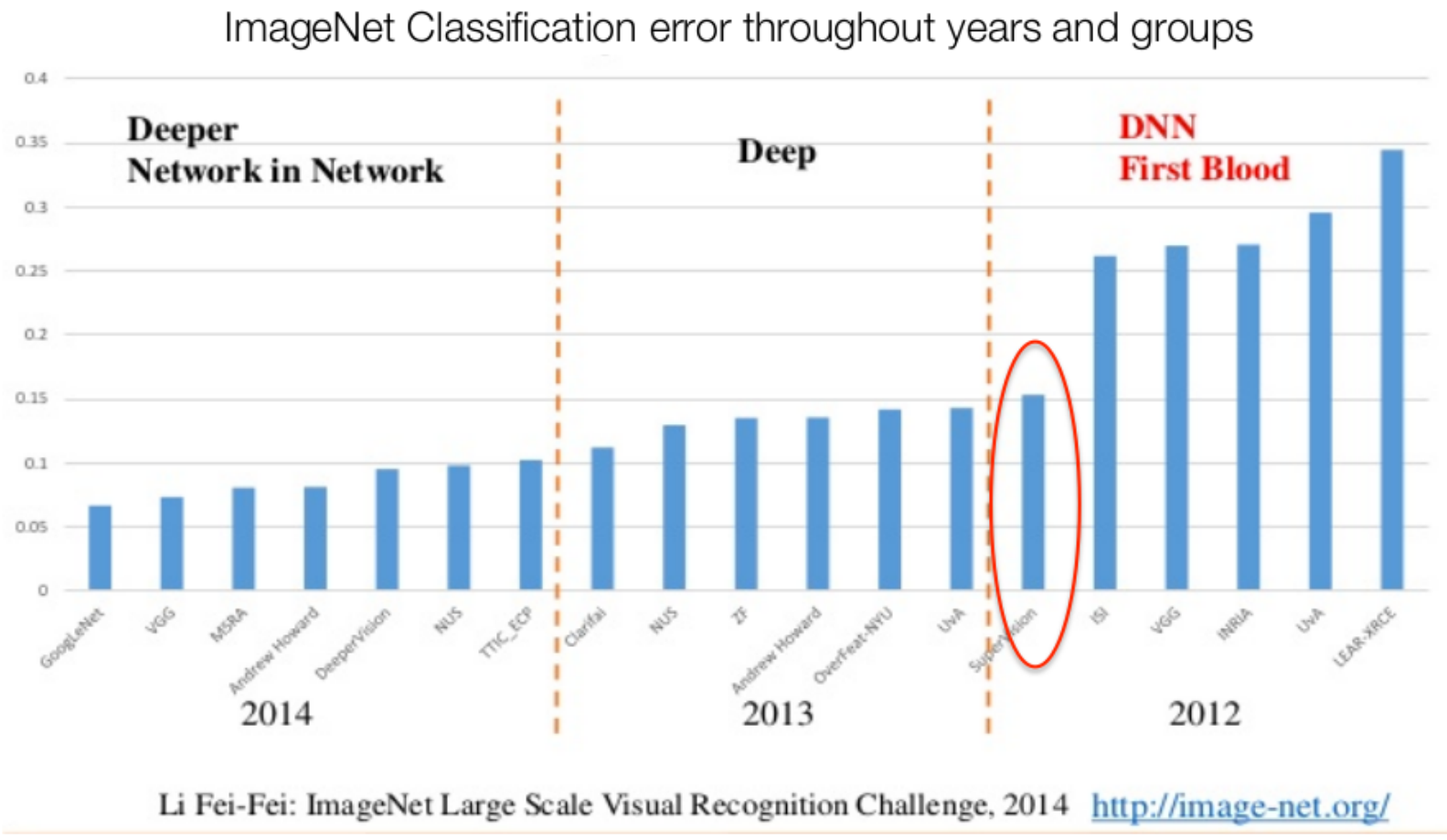
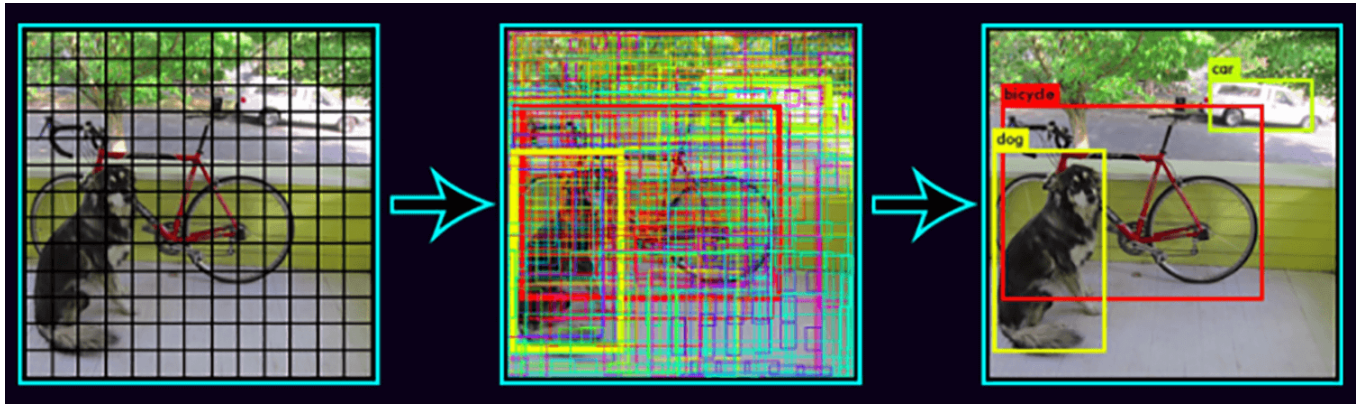


Image Detection

YOLO: Real-Time Object Detection



You only look once (YOLO) is a state-of-the-art, real-time object detection system. On a Pascal Titan X it processes images at 30 FPS and has a mAP of 57.9

Image Segmentation - Scene understanding

Video-to-Video Synthesis

Mimicking style

A neural algorithm of artistic style

L.A. Gatys, A.S. Ecker, M. Bethge

Change the style of an image, preserving the content.

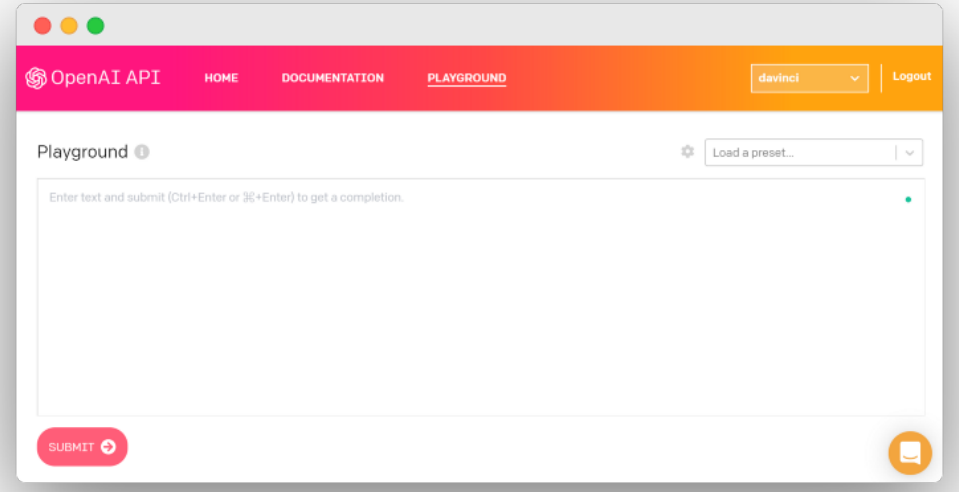
Natural Language Processing

Typical problems in NLP

- Classification, e.g. sentiment analysis: classify a document according to its "polarity".
- Language Modeling (predict the next word/token in a sentence)
- Text summarization/completion
- Machine Translation
- Text Generation: a truly generative task
- Chatbox: a dialog system
- Speech recognition/generation

Examples: GPT3 plyaground, ChatGPT

Generative Pre-trained Transformer 3 (GPT-3) is a recent language model created by OpenAI showing amazing performance. It is one of the largest neural network ever created, with 175 billion parameters, trained over almost all documents avalibale on internet.



Key Technologies

tokenization splitting the input sentence into relevant lexical components (characters/words/**subwords**), and coding them into numbers. Byte-Pair Encoding, WordPiece, SentencePiece, etc.
see this tokenizer summary

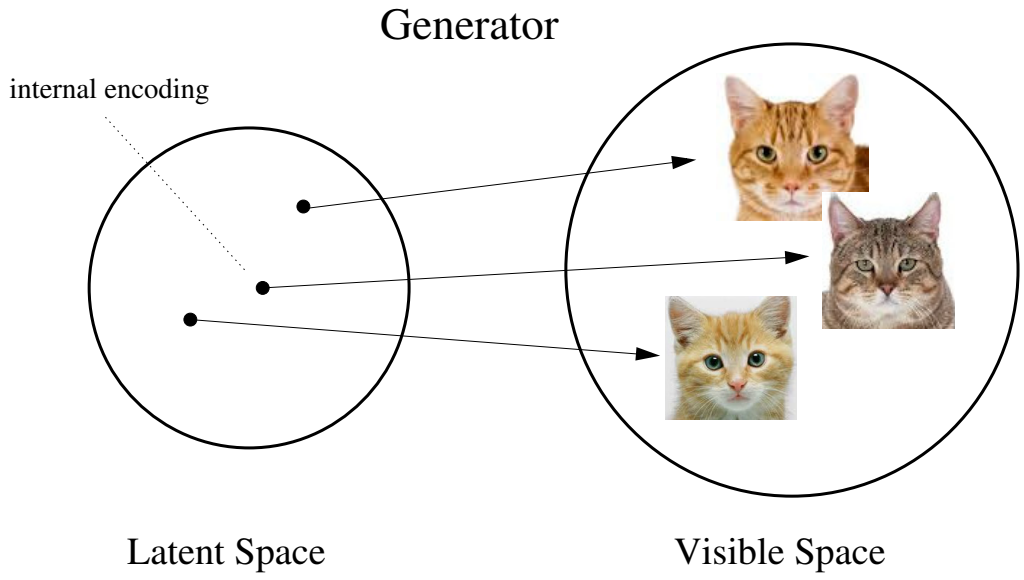
transformers a feed-forward deep learning model adopting **self-attention** for weighting the mutual significance of tokens in the sentence

word embeddings A semantic embedding of words, mostly used for text similarity, text retrieval, code search, etc.
Examples are Word2Vec, Glove.
Transformers do not use them: they learn their own embeddigs.
see this blog for a comparison of state-of-the-art text embeddings.

Generative Modeling

Generative modeling

Train a **generator** able to sample original data similar to those in the training set, implicitly learning the **distribution of data**.

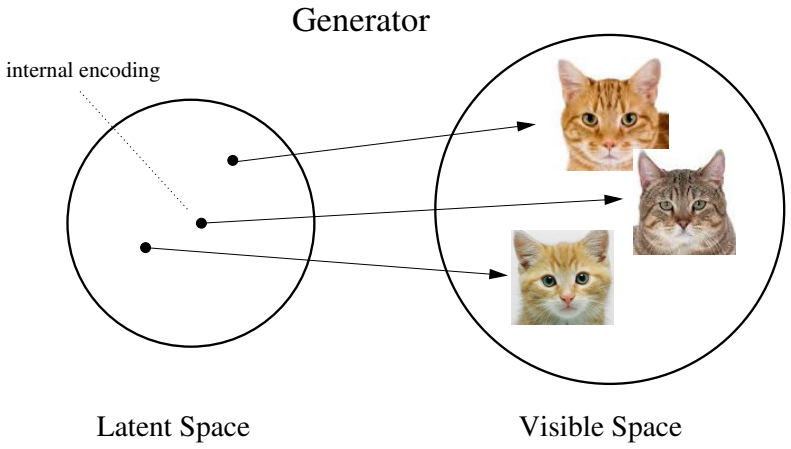


the randomicity of the generator is provided by a **random seed** (noise) received as input

The latent space

Generation is thus a two stage process (ancestral sampling):

- sample z according to a **known prior distribution**
- pass z as input to the generator, and process it

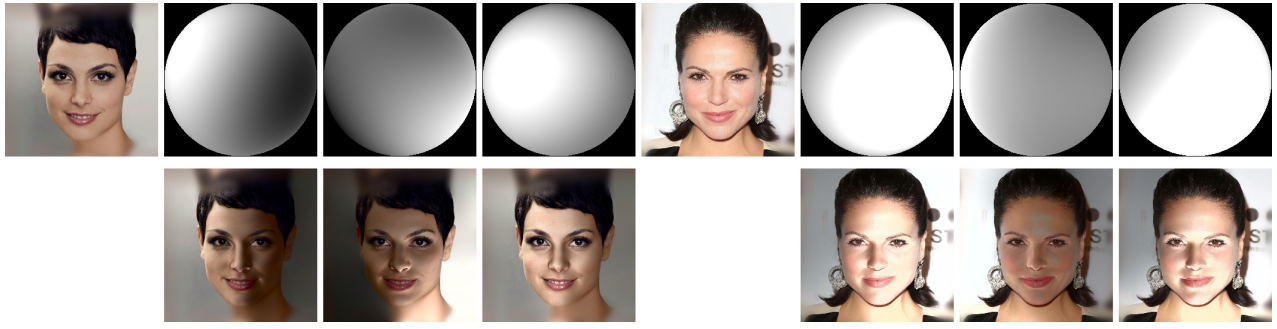


- the seed contains **all information** needed to generate a sample, hence it can be seen as an **encoding** (latent representation) of the given sample.
- seeds must be disseminated with a **known, regular distribution** in their space (the so called prior distribution)
- generattion is a continuous process: small modifications of the seed produce small modifications of the output

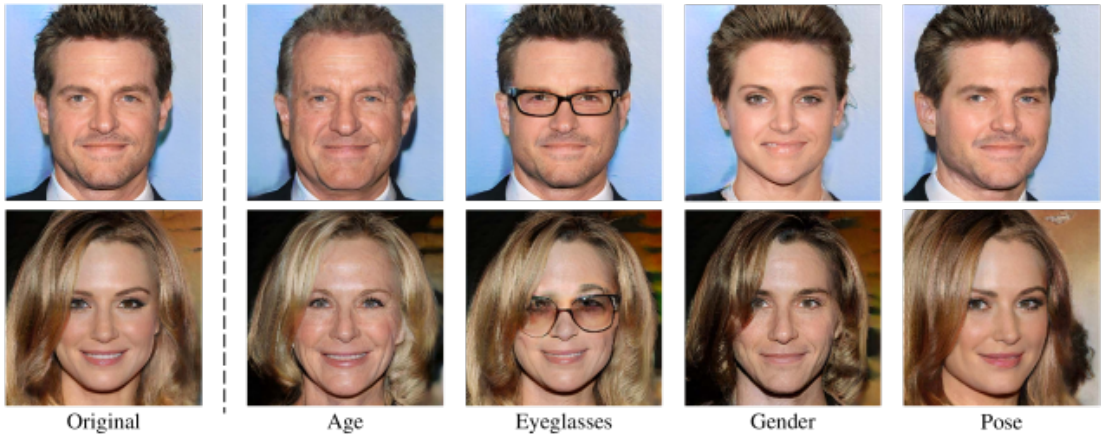
Generative Modeling

Example: Face generation video by Nvidia

Conditional generation

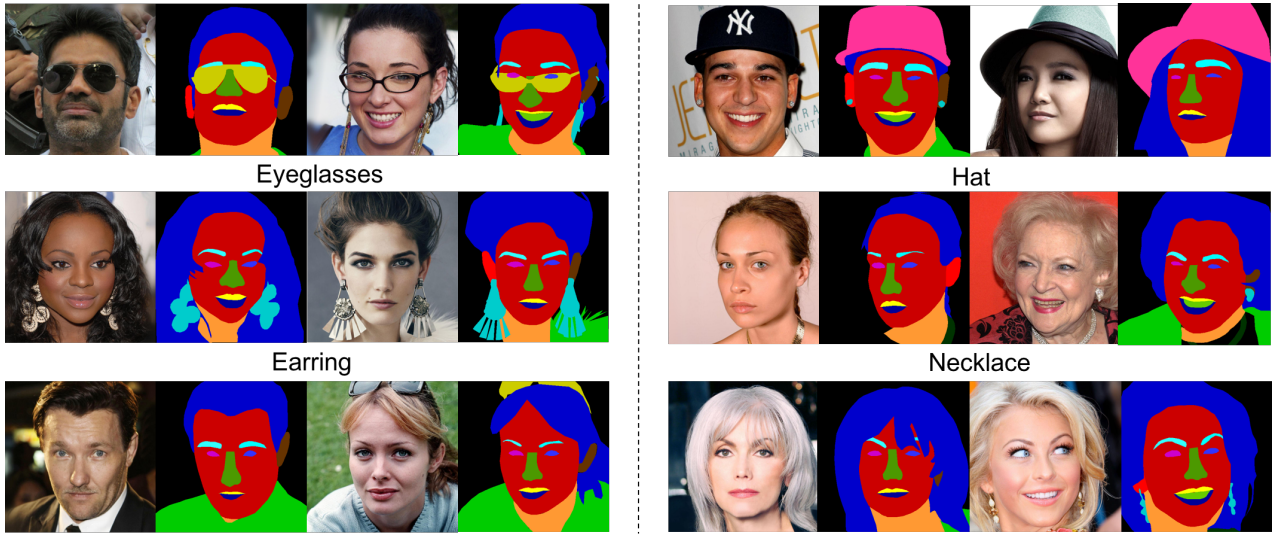


Deep Single Image Portrait Relighting



Interpreting the Latent Space of GANs for Semantic Face Editing

Conditional generation



MaskGAN: Towards Diverse and Interactive Facial Image Manipulation

Caption-conditioning

Dall·E, Imagen and others are new AI systems able to create realistic images and art from a description in natural language.

Embedding

Embedding is the inverse process of generation, namely from visible space to latent space.

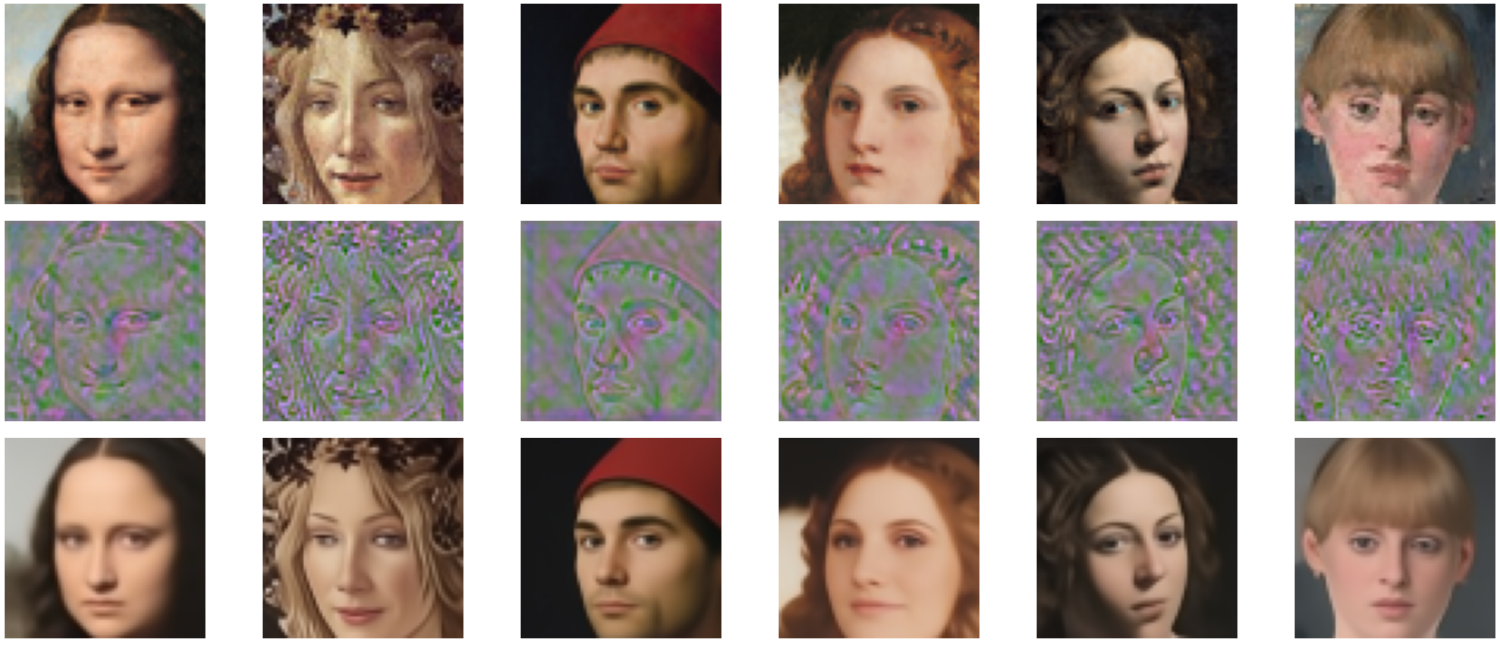
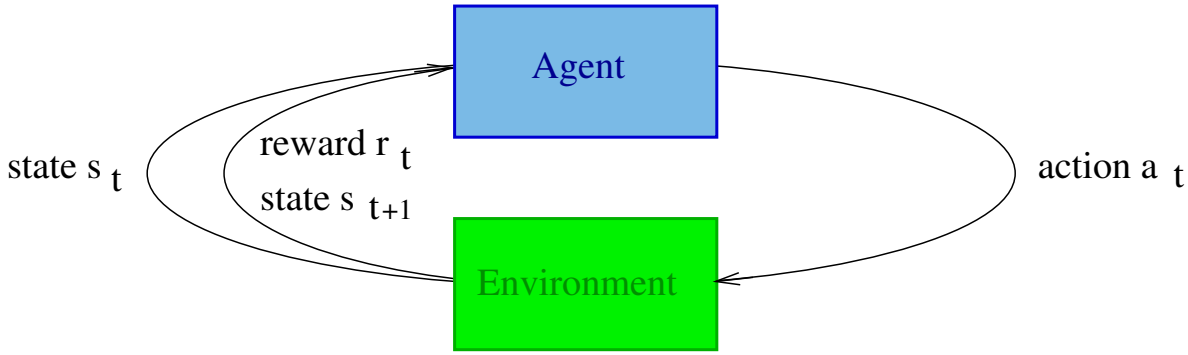


Image Embedding for Denoising Generative Models

Reinforcement Learning

Reinforcement Learning

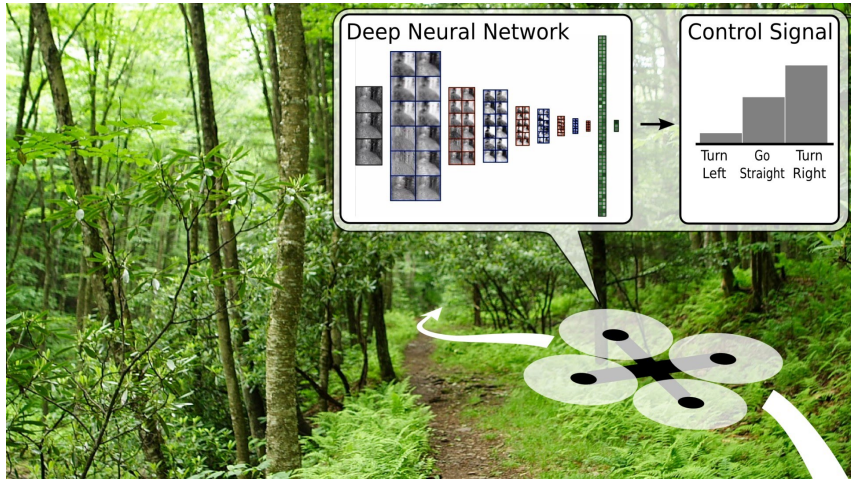
Problems involving an agent interacting with an environment, which provides numeric rewards



Goal: learn how to take actions in order to maximize the future cumulative reward.

Robot navigation

Quadcopter Navigation in the Forest using Deep Neural Networks



Robotics and Perception Group, University of Zurich, Switzerland &
Institute for Artificial Intelligence (IDSIA), Lugano Switzerland

Based on Imitation Learning

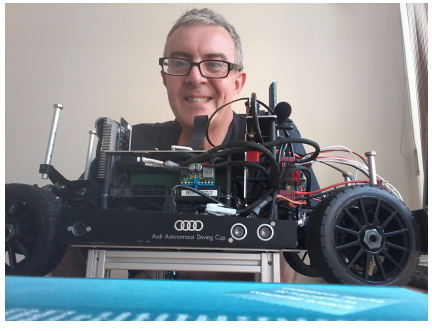
Autonomous driving

Develop intelligent, fully automatic driving functions for vehicles.

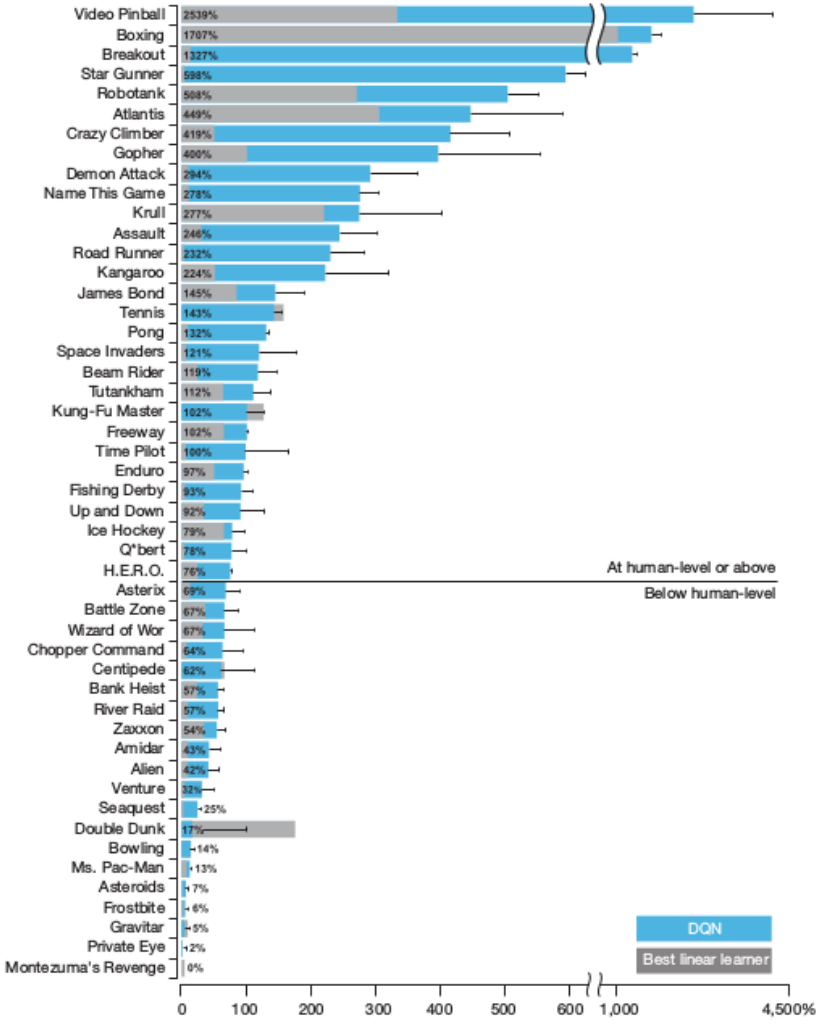
Merging of signals collected by different sensors (camera, lidar, sonar, dots). Needs to accurately evaluate distances and speeds.

Turn observations into actions.

Several competitions around. We took part to the 2018 Audi Autonomous Driving Cup



Game Simulation



Google DeepMind's system playing Atari games (2013)

The same network architecture was applied to all games

End-to-end training starting from screen frames

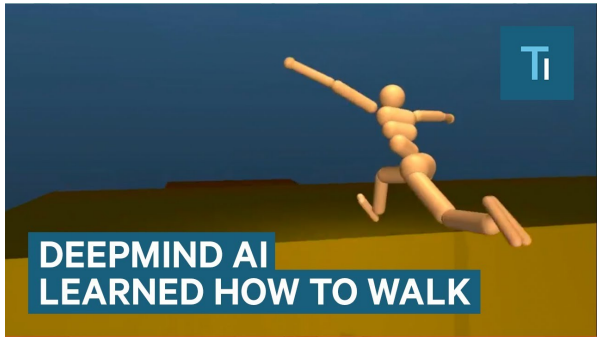
Works well for reactive games; problems with planning...

but see An investigation of Model-Free planning (ICML 2019)

Open AI-gym/gymnasium)

OpenAI Gym (now gymnasium) is a Gym is a toolkit for developing and comparing reinforcement learning algorithms (DQN, A3C, A2C, Acer, PPO, . . .).

It offers many learning scenarios, from walking to playing games like Pong or Pinball, as well as other classical physical "equilibrium" problems.

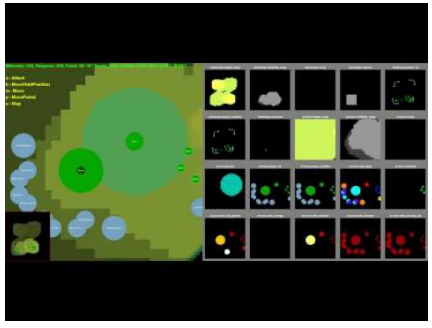


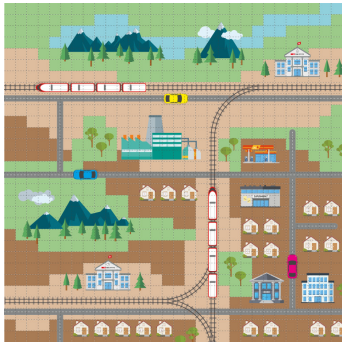
Multi agent DRL

It requires interaction and cooperation of multiple agents.

Examples:

StarCraft II: a RL environment based on the game StarCraft II. The environment consists of three sub-components: a Linux StarCraft II binary, the StarCraft II API providing programmatic control over the game, and a python wrapper over the API called PyC2.





Flatland: a train rescheduling problem on a complex grid world environment.

Flatland is organized every year by Alcrowd in collaboration with the Swiss Federal Railways, SBB